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NOTES ON GEOGRAPHIC DISTRIBUTION

First record of *Micrurus diana* Roze, 1983 (Serpentes: Elapidae) for Brazil and extension of its distribution in Bolivia, with notes on morphological variation

Matheus Godoy Pires [1*], Darlan Tavares Feitosa [2], Ana Lúcia da Costa Prudente [2] and Nelson Jorge da Silva Jr. [3]

1 Museu de Zoologia da Universidade de São Paulo. Avenida Nazaré 481. CEP 04263-000. São Paulo, SP, Brazil.
2 Museu Paraense Emílio Goeldi, Laboratório de Herpetologia. Avenida Perimetral 1901, CP 399. CEP 66040-170. Belém, PA, Brazil.
3 Pontifícia Universidade Católica de Goiás, Programa de Pós-Graduação em Ciências Ambientais e Saúde. Rua 232 n° 128, 3° andar, Área V, Setor Universitário. CEP 74605-140. Goiânia, GO, Brazil.
* Corresponding author. E-mail: *piresmg@gmail.com*

ABSTRACT: *Micrurus diana* is a rare coral snake species poorly represented in museum collections. Based on two recently identified specimens, we report its occurrence for the first time in Brazil and for the Bolivian Yungas, substantially extending its known range. In addition, we also extend the limits of its known morphological variation, based on examination of 11 specimens. Our findings revealed the need of a better characterization for *M. diana*, and the need of preservation efforts for this species and its habitat in Brazil.

Micrurus diana Roze, 1983 was described as a subspecies of *M. frontalis* (Duméril, Bibron and Duméril, 1854) based on five specimens from "vicinity of Santiago" (Serranía de Santiago – 18°15'57" S, 59°43'34" W, 700 m above sea level [asl]), province of Chiquiticos, departamento de Santa Cruz, Bolivia. *Micrurus diana* was originally diagnosed by the fusion of the anterior black ring of the first body triad to the black cephalic cap that covers the parietals and distinguished from *M. frontalis* by having immaculate red rings. Later, the same author elevated it to full species status (Roze 1994) and repeats the same diagnosis, based on the same data (Roze, 1996).

Silva Jr. and Sites (1999) revised the taxonomy of the *Micrurus frontalis* complex and presented additional data on the morphological variation of *M. diana* based on a larger series than the previous works (Roze 1983; 1994; 1996), providing new data on its distribution and variation, and improving the taxon diagnosis. Harvey *et al*. (2003) revised the Bolivian coral snakes, summarized the morphological variation found in four specimens of *M. diana* (NMKR 219, AMNH 120600, FMNH 195864 and FMNH 195899), and suggested that *M. diana* may be synonymous with *M. brasiliensis* Roze, 1967, despite their far allopatric distribution (more than 1000 km). Campbell and Lamar (2004) compiled the available information for *M. diana* and *M. brasiliensis* keeping them as distinct species, although Gutberlet and Harvey (2004) insisted to hypothesize the conspecificity between these taxa on their conjectural "consensus phylogeny of coral snakes".

In order to confirm the identification of the specimens mentioned in this paper, we used as comparative material eleven specimens of *M. diana*, including the complete type-series, housed in the following herpetological collections: American Museum of the Natural History, New York, United States (AMNH); Instituto Butantan, São Paulo, Brazil (IBSP); Field Museum of the Natural History, Chicago, United States (FMNH); Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP); Museu de Historia Natural Noel Kempff Mercado, Santa Cruz de la Sierra, Bolivia (NMKR); Senckenberg Museum of Frankfurt, Germany (SMF); and Zoologisches Museum Hamburg, Germany (ZMH). The description of the cephalic scales and color pattern followed Roze (1996), Silva Jr. and Sites (1999), and Savage and Slowinski (1992). The list of specimens examined is included in Appendix I. Our data include two new records of *Micrurus diana*.

Overall, this publication reports the first known record for *Micrurus diana* in Brazil, extensively increases its known distribution range in Bolivia, and contributes to provide a better understanding of the morphological variation of this species based on a larger series.

MZUSP 17475 (Figure 1): Adult male; snout-vent length (SVL) 1000.00 mm; tail length (TL) 52.00 mm; head length (HL) 29.14 mm; 11 body triads and 1 2/3 triads on the tail; 214 ventral scales; and 21 subcaudal scales (Figures 1a and 1b). Dorsally, the head is black (including rostral, internasals, prefrontals, frontal, and supraoculars) with white bordered scales; parietals completely black (Figure 1c), anterior white ring of the first triad narrower than the others (1 dorsal scale *vs.* 2 – 4 dorsal scales). Laterally, the 1st and 2nd supralabials are white with black posterior border; 3rd and 4th supralabials, nasal and preoculars black with white borders; 5th and 6th supralabials, inferior postocular and temporals red with a brownish posterior border; superior postocular and 7th supralabial red with a black border (Figure 1d). Ventrally, the mental and first pair of infralabials are red with small irregular black markings on the posterior borders; 2nd to 5th pair of infralabials and anterior genials completely red; 6th pair of infralabials and posterior genials with the posterior black tips as part of the anterior black ring of

the first body triad, that includes the 7th infralabials, gular scales and the first preventrals (Figure 1e).

This specimen was collected on May 19th 2008, within the drainage basin of the Parecis hydroelectric power plant reservoir (PCH Parecis), in the municipality of Sapezal (13°4'30.21" S, 58°58'35.29" W, 345 m asl; Figure 2), western Mato Grosso, in the Juruena river basin, about 750 km north from the type-locality and 260 km northeast from the nearest record (NMKR 219 of Serranía de Huanchaca, Santa Cruz, Bolivia).

ZMH-R 2704a (Figure 3): Adult male: SVL 760.0 mm; TL 62.4 mm; HL 20.5 mm; 12 body triads and 1 2/3 on the tail; 217 ventral scales; 27 subcaudal scales (Figure 3a, b). Dorsally, it has white bordered black cephalic scales (including rostral, internasals, frontal, and supraoculars); prefrontals irregularly marked with black; parietals black with red lateral and medial borders (Figure 3c). Anterior white ring of the first triad is narrower than the others (2.5 dorsal scales). Laterally, it presents the 1st and 2nd supralabials, nasal and preoculars white with black posterior borders; 3rd supralabials black with white anterior border and 4th supralabials completely black; 5th and 6th supralabials and temporals red with black posterior border (Figure 3d); inferior postocular completely black; superior postocular and 7th supralabials red with black borders. Ventrally, the mental is black and the first pair of infralabials red with black borders; 3rd to 5th pair of infralabials and first pair of genials completely red; 6th pair of infralabials and second pair of genials red with posterior tip covered by the black coloration of the first ring of the first triad, including the 7th pair of infralabials, gulars, and preventral scales (Figure 3e). This specimen presents white and red rings of the same length and both a little longer than the black rings, keeping the characteristics of immaculate red rings and black tipped white scales.

We identified this specimen during a visit to the Zoologisches Museum Hamburg (Germany), previously identified as *Elaps marcgravii*. It was collected by V. Rolle on 28th May, 1897, in Charopampa, departamento de La Paz, northwestern Bolivia (15°39'0.00" S, 67°55'0.00" W, 749 m asl; Figure 2). This record expands the known distribution of the species about 850 km west-northeast from the type-locality and 550 km from the nearest known record (IBSP 31342) from Jardín Botánico, Santa Cruz de La Sierra.

The sample of 11 specimens analyzed in this work (Appendix 1) not only expands the known distribution of *Micrurus diana*, but also expands the variation range of some diagnostic characters for the species. *M. diana* can have 214 (MZUSP 17475) to 237 (IBSP 31342, SMF 86637) ventral scales [$\overline{x}$ = 223.64 (♂: 214 – 223, $\overline{x}$ = 217.67) (♀: 223 – 237, $\overline{x}$ = 230.8)]; 18 (FMNH 195899) to 27 (ZMH-R 2704a) subcaudal scales [$\overline{x}$ = 22.09 (♂: 21 – 27, $\overline{x}$ = 23.17) (♀: 18 – 23, $\overline{x}$ = 20.8)]; 9 (FMNH 195886, 195889, 195889, AMNH 120600) to 15 (SMF 86637) body triads [$\overline{x}$ = 10.55 (♂: 9 – 12, $\overline{x}$ = 10) (♀: 9 – 15)] and 1 to 1 2/3 tail triads [(♂: 1 1/3 – 1 2/3) (♀: 1 – 1 2/3)]. Red rings of the body can present all range between 3 (ZMH-R 2704a, SMF 86637) to 13 scales in length (often with immaculate scales, but some degree of black-tipping or irregular black scales can be present); white rings present all range between 2 (SMF 86637) to 5 (FMNH 195889) scales in length; the reduced anterior black ring of the first triad (fused with parietals) often have 2 scales in length (3 scales in ZMH-R 2704a);

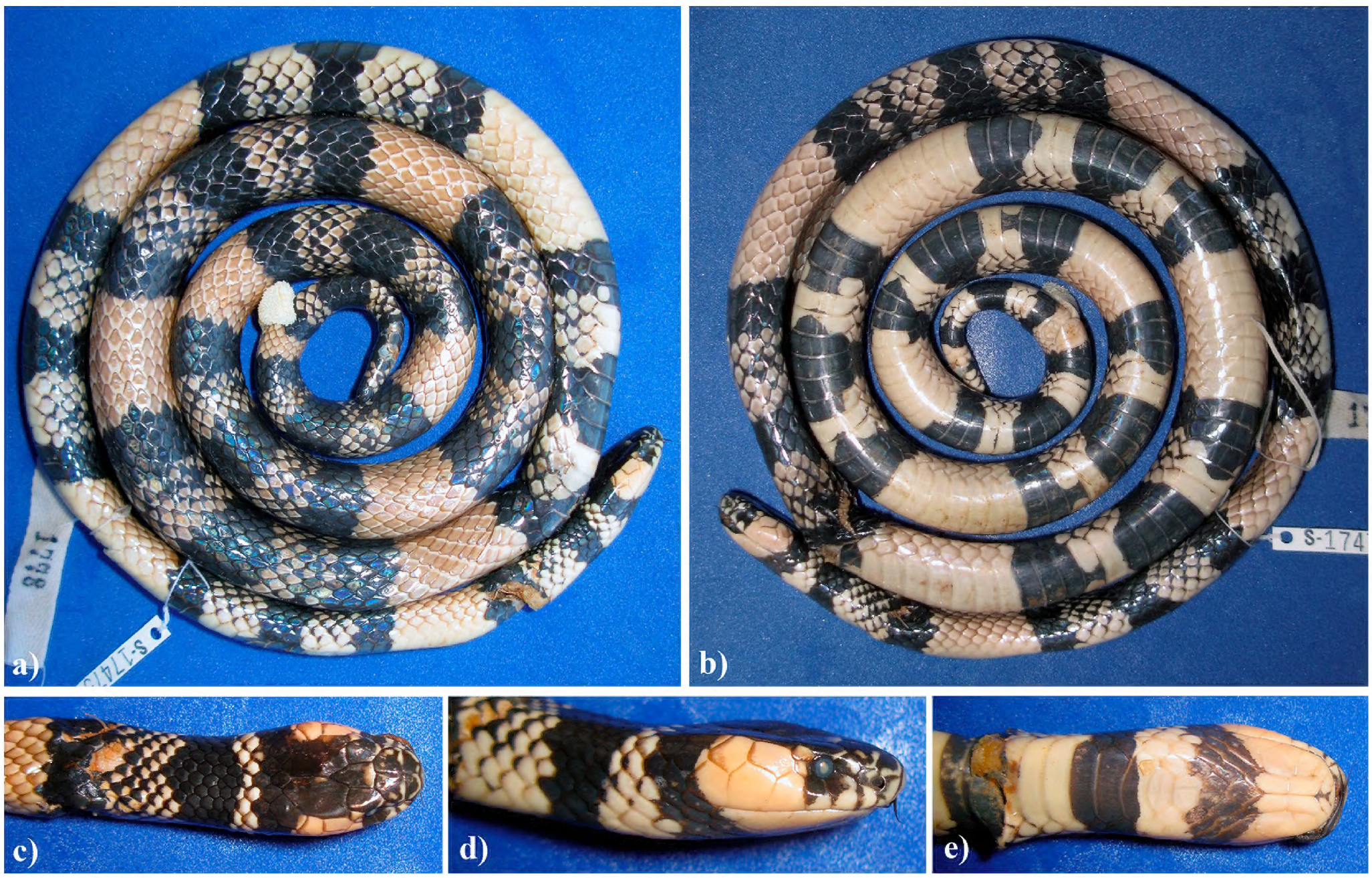

Figure 1. General view of *Micrurus diana* (MZUSP 17475) (SVL: 1000 mm; TL: 52 mm): a) dorsal view of body; b) ventral view of body; c) dorsal view of head; d) lateral view of head; e) ventral view of head (Photos: Paola M. Sánchez Martínez).

nasals divided by nostril opening; 7/7 supralabials, 3rd and 4th in contact with the orbit; one preocular; 2 postoculars; temporals 1+1; 7/7 infralabials (1st to 4th in contact with the anterior genials); anal scale divided. Snout-vent length varying from 573–1000 mm in males ($\bar{x}$ = 804.7; SD = 157.6; n = 7) and 484–925 mm in females ($\bar{x}$ = 673.5; SD = 209; n = 4); tail length varying from 42–62.4 mm in males ($\bar{x}$ = 51.7; SD = 7; n = 7) (4.9–7.2% of total length) and from 32–52.3 mm ($\bar{x}$ = 40.3; SD = 9.1; n = 4) (5.2–6.2% of total length) in females. Head length varying from 20.5–29.1 mm in males ($\bar{x}$ = 23.9; SD = 3.5; n = 7) (2.7–3.6% of SVL) and from 16 – 26.3 mm in females ($\bar{x}$ = 21.5; SD = 4.9; n = 4) (2.8–3.6% of SVL).

Five species of coral snakes are known to occur in Mato Grosso: *Micrurus frontalis* (Duméril, Bibron and Duméril, 1854); *M. lemniscatus helleri* (Schmidt and Schmidt, 1925); *M. paraensis* Cunha and Nascimento, 1973; *M. spixii martiusi* Schmidt, 1953 and *M. surinamensis* (Cuvier, 1817) (Strüssmann and Sazima 1993; Carvalho and Nogueira 1998; Strüssmann and Carvalho 1998). *Micrurus paraensis* can be differentiated from *M. diana* by its tricolor monadal pattern (*vs.* tricolor triadal pattern in *M. diana*) (Savage and Slowinski 1992); *M. surinamensis* having only the 4th supralabials scales in contact with the orbit, black middle ring of the triads wider than the external ones and black bordered red cephalic scales (*vs.* white bordered black cephalic scale coloration, 3rd and 4th supralabials in contact with the orbit, black triad rings of the same length in *M. diana*); *M. lemniscatus helleri* by the completely black snout followed by a transversal white band through the prefrontals and the first triad separated from the black cephalic band by a wide red ring and black infralabials (*vs.* the presence of a black and white snout, absence of a transversal prefrontal white band, black cephalic band fused with the first black body ring in *M. diana*); *M. spixii martiusi* by the first body triad composed by only two black rings and separated from the black cephalic coloration by a red ring (*vs.* first triad fused with the black cephalic coloration, higher number of body triads in *M. diana*); and *M. frontalis* by the absence of fusion of the cephalic black

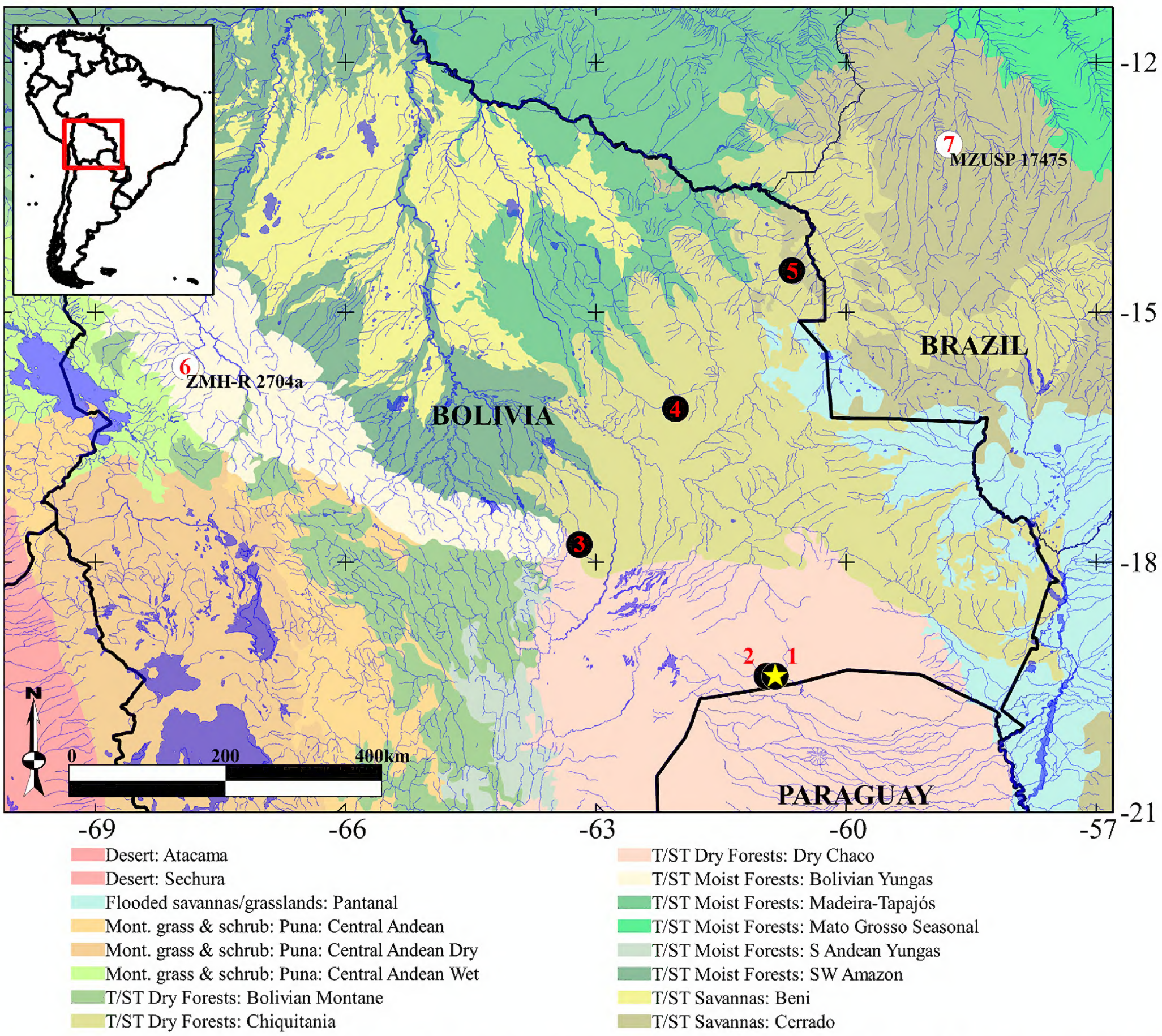

Figure 2. Known distribution of *Micrurus diana*. Star: type locality; white circles: new records; black circles: previously known records. 1) Bolivia, Santa Cruz, Serranía de Santiago; 2) Bolivia, Santa Cruz, Sansaba; 3) Bolivia, Santa Cruz, Santa Cruz de la Sierra; 4) Bolivia, Santa Cruz, San Sebastián; 5) Bolivia, Santa Cruz, Serranía de Huanchaca; 6) Bolivia, La Paz, Charopampa; 7) Brazil, Mato Grosso, Sapezal. Ecoregions following Olson *et al.* (2001).

Figure 3. General view of *Micrurus diana* (ZMH-R 2704a) (SVL: 760.0 mm; TL: 62.4 mm): a) dorsal view of body; b) ventral view of body; c) dorsal view of head; d) lateral view of head; e) ventral view of head (Photos: D. T. Feitosa).

cap with the anterior black ring of the first triad , white rings longer than black rings on the body and usually a higher number of body triads (*vs*. black cephalic cap fused with the first black body ring, white rings longer than black rings and lower mean number of body triads in *M. diana*) (Campbell and Lamar 2004; Silva Jr. and Sites 1999).

Micrurus diana is a rare species of coral snake with few available material on zoological collections, consequently supported by weak diagnosis based on a poorly understood morphological variation. Our data reveals that the previously known variation boundaries on length and appearance of red and white rings, and number of triads for this species were underestimated. The overlap on ventral and subcaudal numbers among taxa within the *M. frontalis* species complex is very common, as previously noted (Silva Jr. and Sites 1999; Di-Bernardo *et al.* 2007). It is important to remember that the diagnosis developed exclusively based on external features are often subject to revision, and internal characters such as skull and hemipenial morphology must be taken into account. On the presence of fused black cephalic caps with anterior rings of the first triad in *M. frontalis*, what was stated by Roze (1983) and repeated by other authors (see Harvey *et al.* 2003; Campbell and Lamar 2004), there is no strong evidence to associate this character to the presently recognized *M. frontalis*. We are aware of only two specimens of *M. frontalis* (MNHN 0.1484 from Caraça, Minas Gerais, and SMF 54734 from São Paulo, both in Brazil) with fusion of the black cephalic cap with the anterior black ring of the first triad, based on expressive sample of 603 specimens. Therefore, fused cephalic cap and white rings longer than black rings of the triads at mid-dorsum are not fixed characters in *M. frontalis* as they are in *M. diana.*

The state of Mato Grosso corresponds to 10.6% of the Brazilian territory, covered by portions of three major vegetational domains in South America: Amazonia, Pantanal and Cerrado (Olson *et al.* 2001). We found *Micrurus diana* in the western Mato Grosso (Cerrado), in a locality condemned to be flooded due to the installation of a private hydroelectric powerplant of low performance (PCH). This region is a very active front of natural landscape substitution. The Cerrado is considered a hotspot of biodiversity, having only 8.21% of its natural area under "legal protection" (MMA, 2013), which by no means assure effective protection to its species, and what raises concern on the survival of *M. diana* in the Brazilian territory. All but ZMH-R 2704a specimens of *M. diana* were collected in landscapes covered by open stands of vegetational structure. The entire type series comes from the Dry Chaco (MZUSP 17475), Cerrado (NMKR 219), and from Chiquitania (NMKR 4253 and IBSP 31342). The specimen ZMH-R 2704a, from the Bolivian Yungas, represents the first record of *M. diana* in the forested habitats (ecoregions following Olson *et al.* 2001).

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Appendix 1. Analyzed material
Type series: BOLIVIA: Santa Cruz: Serranía de Santiago: FMNH 195889 (Holotype); FMNH 195864 (Paratype); FMNH 195899 (Paratype); AMNH 120600 (Paratype); Sansaba, 10 km W of Santiago: FMNH 195886 (Paratype).
Additional material: BOLIVIA: La Paz: Charopampa: ZMH-R 2704a (New record); Santa Cruz: San Sebastián, near Concepción: NMKR 4253, SMF 86637; Santa Cruz de la Sierra: IBSP 31342; Serranía de Huanchaca: NMKR 219. BRAZIL: Mato Grosso: Sapezal: PCH Parecis: MZUSP 17475 (New record).